VIBRATION-CONTROL PLATFORM

Field f the Inventi n

[0001] The present invention relates generally to an article and method for reducing resonances and vibrations that are transmitted to a supported object.

Background of the Invention

[0002] Each musical instrument has its own unique resonance signature. This signature is what makes one type of instrument sound different from another and why two specimens of the same type of instrument do not sound the same. In a piece of music, it is the interplay of these unique resonance signatures that is crucial to conveying the musical idea of a composer, arranger, or performer.

[0003] It is a goal of an audio playback system, in particular a "high-end" audio system, to faithfully reproduce this interplay, as recorded on a recording medium (*e.g.*, lp, cd, tape, *etc.*). To do so, the audio system must extract the recorded musical signal without altering it and convert it to sound.

[0004] Challenging an audio system's ability to faithfully reproduce the recorded musical signal — and hence re-create the original musical event — is the system's susceptibility to mechanical resonances and vibrations. To the extent that an audio system has <u>its own</u> resonant signature, as imparted by such vibrations, it functions as an instrument. Such an audio system will color every instrument that it tries to reproduce, taking the listener further from a faithful re-creation of the original musical event.

[0005] A typical "high-end" audio system will include one or more source components (*e.g.*, cd-player, turntable, *etc.*), a preamplifier, an amplifier and speakers. The spectral signature of these components is affected both directly and indirectly by mechanical resonances and vibrations. As to direct effects, these components are subjected to vibrations and resonances due to:

- *Mechanical coupling*. The most significant source of mechanically-coupled vibration is the music itself. High-amplitude, low-frequency sound from the speakers mechanically couples through the floor of the listening room, up through the equipment rack into the bottom of a component. Furthermore, very-low-level, low-frequency vibrations from passing vehicles, machinery and other sources can couple through the floor into audio components.

- *Acoustic pressure*. Air-borne energy generated by the loudspeaker/room interface can directly couple to equipment racks, equipment enclosures, and then to signal-generating components.
- *Internal vibrations*. Vibrations arise from sub-systems within the audio components themselves, such as mechanical drive systems (*e.g.*, in cd players and turntables, *etc.*), spinning cooling fans (*e.g.*, in amplifiers), and humming transformers. Even electric current moving through wires or other components can be a source of vibration. Specifically, current-induced magnetic fields that form around transformers, wires, and other passive devices can cause these components to vibrate or move slightly within their own fields. This creates minute non-linear currents that can subtly alter the original musical signal.

[0006] As to indirect effects, vibrations, varying in magnitude from very large (*e.g.*, cabinet resonances that can be felt) to miniscule, can negatively affect playback through time- and frequency-domain disturbances.

[0007] To ameliorate the problems wrought by vibrations and resonances, various resonance- and vibration-control products have been developed. The products can be grouped generally into two classes: (1) footers and (2) platforms. Reducing vibrations and resonances through the use of these products has, in some cases, resulted in improvements in imaging, tonal balance, timing, treble focus, bass extension and detail.

[0008] Footers, as the name implies, are devices that are placed underneath an audio component and that replace the manufacturer-supplied "feet" that are supplied with the component (and which typically function simply as a standoff to prevent contact and damage to an underlying support shelf). A variety of footer designs have been developed, two of which are mentioned below.

[0009] In some cases, the footers are formed of a resilient material (*e.g.*, Navcom™ Sorbothane™, *etc.*) that is intended to damp vibrations before they reach the supported component. In some other cases, the footers are rigid (*e.g.*, cones, spikes, *etc.*). Although some rigid footers are alleged by their manufacturers to "drain" energy from the supported component, most function by merely shifting the frequency and level of the resonances.

[0010] While effective to varying degrees, footers have their drawbacks. In particular, they can be difficult to place under audio components, especially if the components are enclosed in a cabinet. Furthermore, footer-supported components

can be somewhat unstable. Resonance/vibration-control platforms address both of these problems.

[0011] Resonance/vibration-control platforms include (1) a base or platform on which the isolated component rests and (2) some type of mechanism for providing resonance/vibration-control for the platform. Several resonance/vibration-control platforms in the prior art are surveyed below.

[0012] One type of system includes one or more air-filled bladders that are located beneath a plinth (typically formed from medium density fiberboard). As the bladders are inflated, the plinth — and hence the component — "float," thereby isolating the component from mechanically-coupled vibrations. In a second type of system, a plinth is placed on a substantial volume of sand. The sand conforms to the entire surface of the plinth and efficiently constrains and partially damps the platform's vibrational modes.

[0013] In a third type of system, several thermally-reactive copolymers are used as the primary damping material. The copolymers are contained in several modules underneath a plinth. Each different copolymer is intended to control resonances within a certain frequency range. The copolymers possess an ability to rapidly change darometer (*i.e.*, relative hardness or softness). Movement or vibration creates friction in the module, which produces heat. The heat changes the darometer of compound in a pre-calculated manner based on the weight of the component it supports. As vibrations pass through the various modules, their amplitude decreases until they are substantially dissipated.

[0014] In a fourth type of system, magnetic levitation is used to isolate a supported component. In this system, coupled magnets that are oriented for repulsion are disposed underneath a plinth.

[0015] These various systems have drawbacks. For example, the technology and materials used in some of these systems are expensive, pushing the retail cost of some of these systems upwards of $1000. In some air-based systems, the air leaks out over time, requiring a user to occasionally re-balance the system by adding more air. For some systems, the customer provides information about the weight, weight distribution, and size of a component of interest and then the resonance/vibration-control system is designed based on these parameters. This limits the suitability of the platform for other equipment should the purchaser decide to replace the component for which the platform was designed. Some systems, such as magnetic

levitation platforms, are particularly sensitive to uneven loads. In this regard, footers have an advantage since they can be appropriately positioned under a component to address an uneven weight distribution.

[0016] Many of the current resonance/vibration-platforms offer little flexibility to adapt to changes in the playback system. And no one resonance/vibration-control system is best for all components (*e.g.*, one manufacturer's turntable vs. another's, *etc.*) in all situations (*e.g.*, room construction, *etc.*). This is problematic because many audiophiles change their playback systems on a regular basis (at least compared to the music-listening public at large). Consequently, an "upgrade" in a source component might <u>downgrade</u> a playback system's ability to reproduce a recorded musical signal because a previous choice in a vibration-control platform is not suited to the new source component. This "upgrade" then occasions another purchase — a new vibration/resonance-control platform that is hopefully better suited to the new source component.

[0017] Consequently, there is a need for an improved resonance/vibration-control system.

Summary of the Invention

[0018] The illustrative embodiment of the present invention is a resonance/vibration-control platform that avoids at least some of drawbacks of the prior art.

[0019] In some embodiments, the resonance/vibration-control platform includes a bottom plate having three or more wells, and more typically about 8 to 25 wells. The wells are physically adapted to receive a plurality of vibration-control elements, which are used to isolate a supported object from vibrations.

[0020] The vibration-control platform is structured so that the vibration-control elements can be readily removed from the wells and replaced with different vibration-control elements. For example, in some embodiments, the vibration-control elements are resilient balls. The balls can be easily placed in the wells or removed from them. Consequently, a user can readily change the vibration-isolating characteristics of the platform. This provides the ability, for example, to adapt to a changing audio system, *etc.*

[0021] Furthermore, the presence of the wells simplifies placement of the vibration-control elements. In particular, it can be difficult to place footer-type vibration-control elements under an object, especially when the object is to be located in a

cramped location, such as in an audio equipment rack. Also, to the extent that the vibration-control elements have a tendency to move after placement, the wells restrict such movement.

[0022] Unexpectedly, the use of rubber balls, in particular, racquet balls or paddle balls, has been found to be particularly effective in reducing the negative effects of vibrations on audio components, as judged by the improved sound quality of playback systems when using the balls.

[0023] The present invention includes other features and provides other benefits, many of which are described in the Detailed Description and illustrated in the appended Drawings.

Brief Description of the Drawings

[0024] **FIG. 1A** depicts a vibration-control platform in accordance with the illustrative embodiment of the present invention.

[0025] **FIG. 1B** depicts an exploded view of the vibration-control platform of FIG. 1A.

[0026] **FIG. 2A** depicts a first variation of a vibration-control platform in accordance with the illustrative embodiment of the present invention.

[0027] **FIG. 2B** depicts an exploded view of the vibration-control platform of FIG. 2A.

[0028] **FIG. 3A** depicts a second variation of a vibration-control platform in accordance with the illustrative embodiment of the present invention.

[0029] **FIG. 3B** depicts an exploded view of the vibration-control platform of FIG. 3A.

[0030] **FIG. 4** depicts a third variation of a vibration-control platform in accordance with the illustrative embodiment of the present invention.

[0031] **FIG. 5** depicts five vibration-control elements disposed on a bottom plate.

[0032] **FIG. 6** depicts six vibration-control elements disposed on a bottom plate.

[0033] **FIG. 7** depicts four vibration-control elements, which are implemented as pucks, disposed on a bottom plate.

Detailed Descripti n

[0034] The illustrative embodiment of the present invention is a vibration/resonance-control platform, which is referred to hereinafter as simply a "vibration-control platform." The vibration-control platform can be used to reduce or otherwise control vibrations and resonances in objects that are disposed on it. In some embodiments, the vibration-control platform is used to control vibrations and resonance in audio or video components. These components include digital and analog source components (*e.g.*, cd-players, dvd-audio players, sacd players, turntables, dvd-video players, *etc.*), amplifiers, preamplifiers, and any other components in the audio or video reproduction chain.

[0035] FIG. 1A depicts a perspective view of vibration-control platform **100** in accordance with an illustrative embodiment of the present invention. In the embodiment depicted in FIG. 1A, vibration-control platform **100** includes bottom plate **102**, top plate **108**, skirt **110** and vibration-control elements **112**.

[0036] FIG. 1B depicts an "exploded" view of vibration-control platform **100**. As depicted in FIG. 1B, fifteen wells **106**, arranged in three rows of five, are disposed on "upper" major surface **204** of bottom plate **102**. Wells **106** receive vibration-control elements **112**. In the illustrative embodiment, four vibration-control elements **112** are disposed in four of the wells, one element at each corner of bottom plate **102**. The bottom surface (not depicted in FIG. 1B) of top plate **108** is supported by vibration-control elements **112**. Consequently, top plate **108**, and the object (*e.g.*, audio component, video component, *etc.*) that it supports, experiences a reduction in (at least) mechanically-coupled vibrations.

[0037] In some embodiments, rather than placing vibration-control elements **112** in wells that are located at the corners of bottom plate **102**, other layouts are used. In those other embodiments, vibration-control elements can be different in the number of elements (*i.e.*, three or more than four), the position of the elements, or both. Some of these other arrangements are described later in this specification.

Balls for use as Vibration-Control Elements 112

[0038] In the illustrative embodiment, vibration-control elements **112** are balls. In some other embodiments, vibration-control elements **112** are cones, pucks, or other devices known for localized vibration/resonance control. (*See*, *e.g.*, FIG. 7 and the accompanying description later in this specification.)

[0039] In some embodiments in which vibration-control elements **112** are balls, they are made from a resilient material, such as rubber. Using resilient balls is beneficial because they provide at least three degrees of freedom in the movement of top plate **108** relative to bottom plate **102**. In particular, when resting on resilient balls, top plate **108** can move up and down, front to back, side to side, in a circular motion, diagonally, *etc.* And the resilience of the balls rapidly damps vibrations.

[0040] And there are other advantages to using resilient balls as vibration-control elements **112**. In particular, they are readily commercially available from a variety of sources (*e.g.*, sporting goods stores, department stores, toy stores, *etc.*), they are inexpensive compared with most vibration-control products, and they are available with a variety of resiliency characteristics (*i.e.*, from relatively softer, spongier balls to relatively harder, less-yielding balls). Harder balls can be used, for example, when platform **100** will be used to support a relatively heavier component. Alternatively, a larger number of relatively softer balls can be used to support the same, relatively-heavier component. (Although the performance of the platform as to its effect on the reproduced music might differ for these two scenarios.) Furthermore, it is believed that the amount of resilience exhibited by a ball (*e.g.*, due to its material of construction, internal pressure, *etc.*) will dictate the effect that the ball has on a given (vibrational) frequency and which specific frequencies it will affect.

[0041] Resilient balls that have been found useful in conjunction with the present invention, and that are readily available, include racquet balls, paddle balls, hand balls, and squash balls. Also, to the extent that different "grades" of a given type of ball are available (*e.g.*, "regular," "tournament," "long-lasting," *etc.*), the various grades will typically exhibit different performance characteristics (as a vibration-control element).

[0042] Although not resilient, solid metal balls of varying metallurgy (*e.g.*, carbide, *etc.*) can be used in conjunction with the illustrative embodiment of the present invention. Further, other types of balls, such as golf balls and plastic balls can suitably be used.

[0043] It will be recognized that the effect that a particular type of ball has on the performance of an audio or video system will be the net result of a variety of factors. Such factors include, without limitation, the characteristics of the ball, the structure of bottom plate **102** and top plate **108**, structural aspects of the component being

supported, structural details of the listening room (*e.g.*, concrete flooring, joist-supported flooring, *etc.*), the design of the equipment stands, *etc.* It is, therefore, very difficult to predict, *a priori*, the effect that a particular type of ball will have on the performance of an audio or video system. Consequently, the effect, and the choice of balls, is best determined empirically. And since the balls are typically widely available and inexpensive, such experimentation is easy.

[0044] Experimentation notwithstanding, it has been discovered that certain rubber balls, in particular, racquet balls and paddle balls, have been found to be particularly effective as a vibration-control element for audio components.

Wells **106**

[0045] Wells **106** are physically adapted (*i.e.*, have an appropriate shape and size) to receive vibration-control elements **112**. For example, in embodiments in which vibration-control elements **112** are balls, the wells are advantageously (but not necessarily) configured as a "dimple" or "concavity" such that they have a hemispherical (or other similar) shape.

[0046] The size of wells **106** is primarily dependent upon the size of vibration-control elements **112**. Consider embodiments in which the vibration-control elements are balls. If wells **106** are too large (*i.e.*, deep), the balls will be deeply recessed. As a consequence, the freedom of the balls to move in response to vibrations might be overly constrained. If wells **106** are too small, overlying top plate **108** might be unstable.

[0047] A well having a diameter (at the surface of bottom plate **102**) in the range of about one-half inch to one and one-quarter inches and a depth of about one-eighth inch to three-eighths inches will be suitable for most balls that are likely to be used as vibration-control elements **112**.

[0048] In the illustrative embodiment, bottom plate **102** includes fifteen wells **106**. In some other embodiments, less than fifteen wells **106** (as few as three) are disposed in bottom plate **102**. And in yet additional embodiments, bottom plate **102** comprises more than fifteen wells **106**.

[0049] One of the benefits of having a relatively large number (*e.g.*, eight or more) of wells **10¯** in bottom plate **102** is that a relatively greater number of vibration-control elements **112**, and non-rectangular arrangements thereof, are readily accommodated. A relatively greater number of vibration-control elements **112**

might be required, for example, to support a relatively heavy object. Furthermore, the presence of a relatively large number of wells that are distributed across bottom plate **102** provides an ability to easily position the vibration-control elements as desired. This capability is particularly useful for supporting an object having a very non-uniform weight distribution or unusual shape. (*See*, *e.g.*, FIGs. 5-6 and the accompanying description later in this specification.)

[0050] In embodiments in which rubber balls are used as vibration-control elements **112**, the number of wells on bottom plate **102** is typically in the range of 8 to 25 (*e.g.*, 2x4, 3x3, 3x4, 3x5, 3x6, 4x4, 4x5, 4x6, 5x5, *etc.*) as a function of the size of bottom plate **102**. More typically, the number of wells on bottom plate **102** is in the range of 12 to 25. All embodiments of the present invention have at least three wells **106**.

Bottom Plate **102**, Top Plate **108** and Skirt **110**

[0051] Skirt **110** depends from a marginal region of the lower surface of top plate **108**. The skirt increases the rigidity of top plate **108** and also serves to at least partially obscure vibration-control elements **112** from view. The perimeter of skirt **110** is somewhat larger than bottom plate **102**, thereby ensuring that any vertical or horizontal movement of top plate **108** does not result in contact between the skirt and bottom plate **102** or vibration-control elements **112**. Furthermore, the height of skirt **110** is such that it will not contact the surface (*e.g.*, a table, component rack, *etc.*) that supports bottom plate **102**. The height of skirt **110** will therefore be a function of the thickness of bottom plate **102**, the depth of wells **106**, the height of vibration-control elements **112**, and the desired clearance.

[0052] In some embodiments, bottom plate **102**, top plate **108**, and skirt **110** are formed from acrylic, such as Acrylite™, commercially available from Cryo Industries of Rockaway, NJ or others. The use of acrylic is advantageous for vibration control because its complex, dense, and irregular molecular structure is believed to hinder propagation of vibrations. In other embodiments, other materials can suitably be used (*e.g.*, any of a variety of woods, glass, other plastics, *etc.*). The combination of rubber balls as vibration-control elements **112** and an acrylic bottom plate **102**, top plate **108**, and skirt **110** have been found to be particularly advantageous when the supported object is an audio or video component.

[0053] In some embodiments, bottom plate **102** is supported by a plurality (typically, three, four or six) rubber feet **114**. The feet prevent damage to the underlying

support surface and also provide an additional measure of vibration isolation. In some embodiments, the feet are attached to bottom plate **102** (*e.g.*, bonded, screwed, *etc.*). In some other embodiments, additional wells (not depicted) can be formed on bottom surface **116** of bottom plate **102**. In those embodiments, vibration-control elements **112** are positioned for use as the footers.

Some Variations of the Illustrative Embodiment

[0054] FIGs. 2A and 2B (exploded view) depict a variation of the illustrative embodiment wherein vibration-control platform **100** includes top plate **108**, skirt **110**, vibration-control elements **112**, and receivers **218** for receiving the vibration-control elements. A bottom plate (*i.e.*, bottom plate **102**) is not included. Like wells **106** in bottom plate **102**, receivers **218** facilitate placement and control of vibration-control elements **112**. In some embodiments, as few as three receivers **218** and three vibration-control elements **112** are used.

[0055] FIGs. 3A and 3B (exploded view) depict a further variation of the illustrative embodiment wherein vibration-control platform **100** includes bottom plate **102**, top plate **108**, and vibration-control elements **112**. In this variation, top plate **108** does not include skirt **110**. This variation is less costly to manufacture than the illustrative embodiment depicted in FIGs. 1A and 1B, but is arguably less aesthetic than the illustrative embodiment since vibration-control elements **112** are readily visible.

[0056] FIG. 4 depicts yet a further variation of the illustrative embodiment, wherein vibration-control platform **100** includes bottom plate **102** and vibration-control elements **112**, but not top plate. In this variation, the object being supported rests directly on vibration-control elements **112**.

[0057] As previously described, in some embodiments, more than four vibration-control elements **112** are used in conjunction with vibration-control platform **100** and, further, in some embodiments, the vibration-control elements **112** are positioned in non-rectangular arrangements. Two examples of such embodiments are depicted in FIGs. 5 and 6.

[0058] FIG. 5 depicts an embodiment in which five vibration-control elements **112** are disposed in five wells **106** in bottom plate **102**. This arrangement might be used to support a component having an uneven weight distribution. A further embodiment depicted in FIG. 6 shows six vibration-control elements **112** disposed in

six wells **106**. This arrangement might be used to support a relatively heavier component.

[0059] It was previously disclosed that in embodiments in which vibration-control elements **112** are not balls, wells **106** might not have a dimpled or hemispherical shape. For example, if vibration-control elements **112** are pucks, as in the embodiment depicted in FIG. 7, then wells **106** are advantageously implemented as a plurality of flat, circular depressions.

Example

[0060] By way of example, platforms in accordance with the illustrative embodiment have been built with the following dimensions:

Top platform **108**:	18 in. (length) x 14 in. (width) x 2½ in. (thickness) [including skirt **110**]
Bottom platform **102**:	14 in. (l) x 12 in. (w) x ½ in. (thickness)
Number of wells **106**:	15 (3 rows of 5 wells each)
Size of wells **106**:	1 in. diameter and a maximum of ¼ inch deep

[0061] It is to be understood that the above-described embodiments are merely illustrative of the present invention and that many variations of the above-described embodiments can be devised by those skilled in the art without departing from the scope of the invention. It is therefore intended that such variations, and others that will occur to those skilled in the art in view of the present disclosure, be included within the scope of the following claims and their equivalents.